CLAIMS:

1. A diffraction grating with periodically arranged protrusions and grooves, wherein the protrusions are made of a material whose index of refraction is greater than the index of refraction of the grooves, and a ratio of a width D of the protrusion to a pitch Λ of the protrusion is set equal to or less than 0.4 ($D/\Lambda \leq 0.4$).

2. A diffraction grating with periodically arranged protrusions and grooves, wherein the protrusions are made of a material with a second refractive index n2 that is greater than a first refractive index n1 of the grooves (n2>n1), and the ratio of the width D of the protrusion to the pitch Λ of the protrusion satisfies the condition

$$D/\Lambda = (1/2)\exp(-3\Delta n * Q/2)$$

where $\Delta n = n2 - n1$, and Q is a value defining the shape and the thickness of the diffraction grating and expressed as $Q = 2\pi\lambda T/n\Lambda^2$, where T denotes the depth

of the groove, n denotes the average refractive index of the diffraction grating, and λ is the wavelength of light incident on the diffraction grating.

3. The diffraction gratings according to claim 2, wherein the Q value is greater than 1 (Q>1).

4. The diffraction grating according to claim 2, wherein the diffraction grating is formed using a mask pattern modified so that a bright and dark ratio is offset from 1, and that condition $D/\Lambda \leq 0.4$ is satisfied.

5. The diffraction grating according to claim 1 or 2, wherein the protrusions are made of a birefringent material, and the grooves are filled with an

isotropic material.

6. The diffraction grating according to claim 5, wherein the birefringent material is an organic polymer.

7. The diffraction grating according to claim 5, wherein the birefringent material is liquid crystal.

8. The diffraction grating according to claim 1 or 2, wherein the diffraction grating has wavelength selectivity to allow a first light beam with wavelength of $\lambda 1$ to pass through, and to diffract a second light beam with wavelength of $\lambda 2$.

9. An optical pickup comprising:

a light source for emitting a light beam;

a condensing lens for guiding the light beam onto an optical recording medium;

a diffraction grating positioned on an optical path extending between the light source and the optical recording medium; and

a photodetector for receiving a portion of the light beam reflected from the optical recording medium and diffracted by the diffraction grating, the diffraction grating having periodically arranged protrusions and grooves, the protrusions being made of a material with an index of refraction greater than the index of refraction of the grooves, and a ratio of a width D of the protrusion to a pitch Λ of the protrusion being set equal to or less than 0.4 ($D/\Lambda \leq 0.4$).

10. An optical pickup comprising:

a light source for emitting a light beam;

a condensing lens for guiding the light beam onto an optical recording medium;

a diffraction grating positioned on an optical path extending between the light source and the optical recording medium; and

a photodetector for receiving a portion of the light beam reflected from the optical recording medium and diffracted by the diffraction grating,

wherein the diffraction grating has periodically arranged protrusions and grooves, the protrusions are made of a material with a second refractive index n2 that is greater than a first refractive index n1 of the grooves (n2>n1), and a ratio of a width D of the protrusion to the pitch Λ of the protrusion satisfies the condition

$$D/\Lambda = (1/2)\exp(-3\Delta n * Q/2)$$

where $\Delta n = n2 - n1$, and Q is a value defining the shape and the thickness of the diffraction grating and expressed as $Q = 2\pi\lambda T/n\Lambda^2$, where T denotes the depth of the groove, n denotes the average refractive index of the diffraction grating, and λ is the wavelength of light incident on the diffraction grating.

11. A diffraction optical element having a grating with a variable pitch, wherein a duty of the grating is set variable in accordance with the pitch, where the duty denotes a ratio of the width of a protrusion of the grating to the pitch of the grating.

12. The diffraction optical element according to claim 11, wherein the grating is formed using a birefringent material, the grating includes a first grating portion with a first pitch and a second grating portion with a second pitch that is greater than the first pitch, and the duty of the first grating portion is set smaller than that of the second grating portion, depending on the birefringence of the birefringent material.

13. The diffraction optical element according to claim 11, wherein the grating is formed using a

birefringent material, the grating includes a first grating portion with a first pitch and a second grating portion with a second pitch that is grater than the first pitch, and the duty of the first grating portion is set greater than that of the second grating portion, depending on the birefringence of the birefringent material.

14. The diffraction optical element according to claim 11, wherein the duty of the grating with the variable pitch is determined in a variable manner so that the diffraction efficiency of the grating becomes uniform throughout the entire grating.

15. The diffraction optical element according to claim 11, wherein the grating with the variable pitch is formed in an optically anisotropic and birefringent material, and grooves of the grating are filled with an isotropic material.

16. The diffraction optical element according to claim 15, wherein the optically anisotropic and birefringent material is a drawn film of organic polymer.

17. The diffraction optical element according to claim 11, wherein the grating with the variable pitch is formed in an optically isotropic material, and grooves of the grating are filled with an optically anisotropic and birefringent material.

18. The diffraction optical element according to claim 17, wherein the optically anisotropic and birefringent material is liquid crystal.

19. A diffraction optical element divided into a plurality of grating regions, each of the grating regions having a grating with a prescribed pitch that is different from pitches of the other grating regions, and each of the grating regions having a different duty, where the duty denotes the ratio of the width of a protrusion of the grating region to the pitch of the grating region.

20. The diffraction optical element according to claim 19, wherein the grating of each of the grating regions is formed using a birefringent material, and the duty of the grating region with the smallest pitch is set less than the duties of the other grating regions, depending on the birefringence of the birefringent material.

21. The diffraction optical element according to claim 19, wherein the grating of each of the grating regions is formed using a birefringent material, and the duty of the grating region with the smallest pitch is set greater than the duties of the other grating regions, depending on the birefringence of the birefringent material.

22. The diffraction optical element according to claim 19, wherein the duty of each of the grating regions is determined so that the diffraction efficiencies of the grating regions become substantially equal to each other.

23. The diffraction optical element according to claim 19, wherein the grating of each of the grating regions is formed in an optically anisotropic and birefringent material, and grooves of the grating are filled with an isotropic material.

24. The diffraction optical element according to claim 23, wherein the optically anisotropic and birefringent material is a drawn film of organic polymer.

25. The diffraction optical element according to claim 19, wherein the grating of each of the grating regions is formed in an optically isotropic material, and grooves of the grating are filled with an optically anisotropic and birefringent material.

26. The diffraction optical element according to claim 25, wherein the optically anisotropic and birefringent material is liquid crystal.

27. A method for fabricating a diffraction optical element that includes a grating comprised of alternately arranged protrusions and grooves, the method comprising the steps of:

preparing a photo mask having a grating pattern with a variable pitch and with a duty variably adjusted in accordance with the pitch, where the duty corresponds to a ratio of the width of the protrusion of the grating to a protrusion pitch, and

forming the grating using the photo mask, wherein the mask duty is variably adjusted so that the diffraction efficiency of the grating becomes uniform throughout the entire grating.

28. The method according to claim 27, further comprising the steps of:

forming an optically anisotropic and birefringent material layer on a substrate;

etching the optically anisotropic and

birefringent layer using the photo mask to form the grating; and

filling the grooves of the grating with an optically isotropic material.

29. The method according to claim 27, further comprising the steps of:

forming an optically isotropic material layer on a substrate;

etching the optically isotropic material layer using the photo mask to form the grating; and

filling the grooves of the grating with an optically anisotropic and birefringent material.

30. A method for fabricating a diffraction optical element divided into a plurality of grating regions, each grating region including a grating with a different grating pitch, the method comprising the

steps of:

preparing a photo mask having a grating pattern divided into a plurality of sub-regions, each sub-region having a different mask pitch and a different mask duty, where the mask duty corresponds to a ratio of the width of a protrusion of the grating to a protrusion pitch, and

forming the grating using the photo mask, wherein the mask duty of each sub-region is determined so that the diffraction efficiency of the diffraction optical element becomes uniform throughout the grating regions.

31. The method according to claim 30, further comprising the steps of:

forming an optically anisotropic and birefringent material layer on a substrate;

etching the optically anisotropic and birefringent layer using the photo mask to form the grating of each of the grating regions; and

filling grooves of the grating with an optically isotropic material.

32. The method according to claim 30, further comprising the steps of:

forming an optically isotropic material layer on a substrate;

etching the optically isotropic material layer using the photo mask to form the grating of each of the grating regions; and

filling grooves of the grating with an optically anisotropic and birefringent material.

33. An optical pickup device comprising:

a light source for emitting a light beam;

a condensing lens for guiding the light beam onto an optical recording medium;

a diffraction optical element positioned on an optical path extending between the light source and the optical recording medium; and

a photodetector for receiving a portion of the

light beam reflected from the optical recording medium and diffracted from the diffraction grating, the diffraction optical element having a grating with a variable pitch, and a duty of the grating being set variable in accordance with the pitch, where the duty denotes a ratio of the width of a protrusion of the grating to the pitch of the grating.

34. An optical pickup device comprising:

a light source for emitting a light beam;

a condensing lens for guiding the light beam onto an optical recording medium;

a diffraction optical element positioned on an optical path extending between the light source and the optical recording medium; and

a photodetector for receiving a portion of the light beam reflected from the optical recording medium and diffracted from the diffraction grating, the diffraction optical element being divided into a plurality of grating regions, each grating region having a grating with a different pitch, and a duty of the grating of each of the grating regions being

set in accordance with the associated pitch, where the duty denotes a ratio of the width of a protrusion of the grating region to the pitch of the grating region.

35. An optical disk drive comprising an optical pickup described in any one of claims 9, 10, 33 and 34, for recording and reproducing information in and from, respectively, a recording medium.